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Frank J. Blaha
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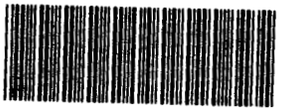

PAST ACCIDENTAL RELEASES OF RADIOACTIVITY FROM THE ROCKY FLATS PLANT

by

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ENVIRONMENTAL SCIENCES DEPARTMENT

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A REVIEW OF THE SEPTEMBER 11, 1957 FIRE AT THE ROCKY FLATS PLANT IN PLANT BUILDING NUMBER 771

INTRODUCTION AND SUMMARY

Smoke from a burning glove, detected in a building hallway, led two watchmen to discover flames extending 18 inches out of a Plexiglas window on a glovebox. The time was approximately 10 10 p.m , Wednesday, September 11, 1957. The fire had started in a 3 inch high by 5 inch diameter can of plutonium turnings in the "fabrication development line" in Room 180, (first floor) of the plutonium processing and fabrication building (Building 771) of the Rocky Flats Plant near Golden, Colorado. Fires in the box exhaust booster filters and main filter plenum on the second floor may have also been started around this time but were not discovered until 10:28 p.m. An explosion of collected flammable vapors in the main exhaust duct at 10:39 p.m. resulted in spreading plutonium through most of the building and probably contributing to the release of plutonium from the 152 foot tall stack.

The fire in Room 180 was controlled at 10:38 p.m. but rekindled several times. The main filter fire was controlled at 2:00 a.m., September 12 and the fire was officially declared out at 11:30 a.m., Thursday, September 12, 1957.

This incident resulted in an $818,600 AEC property loss and an uncertain environmental release of plutonium and associated radioactivity. Estimates of this release are given as follows.

1. "detectable but insignificant[a]," J. Epp, 771 Building Fire Report

2. "25,618 Microcuries recorded stack release[b]," M. A Thompson, 1975 Omnibus and 1977 Draft Rocky Flats Environmental Impact Statement ERDA-1545-D, 1980 Final Rocky Flats Environmental Impact Statement DOE/EIS-0064

3. "1 gram of plutonium offsite[c]," S. E. Hammond, 1971 LASL Meeting Report LA-4756

4. 1.0 ± 0.3 Ci (14 grams) total plutonium release[d], ... Barrick, 1980

The rationale behind these release estimates is explained in the following referenced paragraphs

a. "Insignificant" compared to the 1957 industry and governmental standards. For instance, the maximum permissible level for workers was 9 dpm total long lived alpha (TLLα) activity per cubic meter of air. For comparison the only offsite air sampler with detectable TLLα activity was located near Wagner School. From September 10-13, it sampled 4320 m^3 of air and gave an activity of 0.05 dpm/m^3. The eight onsite air samplers operating from September 11, 8:15 a.m. to September 12, 3:30 p.m. showed no detectable activity. The detection limit was 0.009 dpm/m^3 for three day air samples. No offsite surface readings of direct count were above background. The average offsite removable TLLα activity was 4.2 dpm/100 cm^2. The highest was 24 dpm/100 cm^2 at Ward Road and the C&S Railroad tracks. The plant accepted offsite removable activity limit was 50 dpm/100 cm^2. The average onsite removable activity was 6.3 dpm/100 cm^2 The highest, 51 dpm/100 cm^2, was from the 991 Building roof.

b. Several assumptions were made concerning the exhaust air flow rates September through October 1957 and concerning the time represented by the recorded average daily releases "before" and "after the incident." Subsequent authors (Hobbs, Hornbacher, Kittinger, Thompson) additionally assumed that the amount recorded at the stack sampler September through December 1957, minus the average (of normal 1957 months) stack sampler readings was the best estimate of the 1957 fire

release. This is the basis of the 25,618 μCi release value. There is no way to accurately quantify the release from fact sampler data because the concentration (dpm/m^3) and the flow rate was unknown and fluctuating between 10 and 12 p m September 11, 1957.

c. "Offsite" meant outside the cattle fence which in 1957 was the USAEC property line enclosing the approximately four square mile plant site. There are several drafts of this report with more explicit maps and data back to March 1958. The first mention noted of "one gram offsite" was in a 1970 draft of Report LA 4756. Monthly progress reports and personal data files were searched but no statement of basis, assumptions, method or calculation was found to indicate the actual derivation of Hammond's estimate.

d. This estimate was made for this report by the author assuming the southern most branch of the soil activity deposition, best illustrated by Krey (1976 Health Physics 130, pp 209-214), was due to the '57 fire. Wind speed and direction data from atop 123 Building in 15 minute intervals was used to predict the expected path of releases from the 771 stack. The accuracy of these assumptions was checked where possible by vegetation sampled September 12 and 13 (and continued through October 1957) and analyzed for plutonium. This model was used to deconvolute the Krey 1976 estimate of Rocky Flats plutonium in Denver area soils (11.4 Ci) into that small portion due to the 1957 fire and the remaining larger portion presumed from the oil barrel leak (1958-1969). The release track was taken as the axis of symmetry and the portion of the Krey, 1976, contours west of this axis were rotated to provide closed and deconvoluted contours due to the '57 fire. The larger remainder fit a soil deposition model based on

vector analysis of the 17 year wind rose. Here it is assumed the deposition pattern axis of symmetry followed the summation of vectors where the wind direction gave the angle and the quantity $(v - 5)^3$ = vector magnitude with $\bar{v}$ being the average wind speed in mph (Fuchs "The Mechanics of Aerosols," Chap. VIII, 1960)

Other available information sources such as air sample results, removable activity on surfaces, soil sample activity measurements and isotopic ratio measurements were cross-checked to verify deposition of plutonium to the southeast in 1957 rather than during the period 1958-69 assumed by Seed, et al., in RFP INV 10 (1971) and Krey (1970)(1976). Both authors stated the 1957 fire release was not explicitly included in the basis of their estimates, probably due to the obviously larger (approximately 90 percent) fraction of deposition due to the barrel leak and also the uncertainties in the 1957 plutonium stack release estimates.

A REVIEW OF THE ROCKY FLATS PLANT WASTE OIL DRUM LEAK INCIDENT (1958-1970)

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INTRODUCTION

Seed[1] reports that 5,240 thirty and fifty-five gallon steel drums containing up to 262,000 gallons (Maas[15]) of waste organic liquids were stored in an area (Figure 1 and 2) established for temporary storage in July 1958 inside the Rocky Flats Plant security fence. These liquids were mainly machining lubricants and chlorinated solvents originating in plutonium (3,570 drums), uranium and miscellaneous (1,670 drums) operations. Storage of the plutonium containing oil drums started Septebmer 1958 (Hill[14]) and ended January 24, 1968. All other drums were removed from the storage area by June 5, 1968.

ESTIMATES OF PLUTONIUM STORED AND LEAKED

There is no leakage information on the uranium and miscellaneous operations drums, but Seed[1] reports an estimated 5,000 gallons of "oil" containing 85 grams (42 to 170 grams) of plutonium leaked into the soil. This amount was obtained from a Maas[15] estimate as follows: The maximum estimated volume of oil stored is subtracted from the measured volume of oil recovered. This quantity is multiplied by the plutonium concentration measured in the recovered oil. The maximum estimate of 85 grams plutonium was thus obtained.

The material balance inventory reported by Seed[1] and Maas[15] is shown in Table 1

FIGURE 1

(FROM REF 14)

LOCATION AIR SAMPLER AND DRUM STORAGE AT THE ROCKY FLATS PLANT

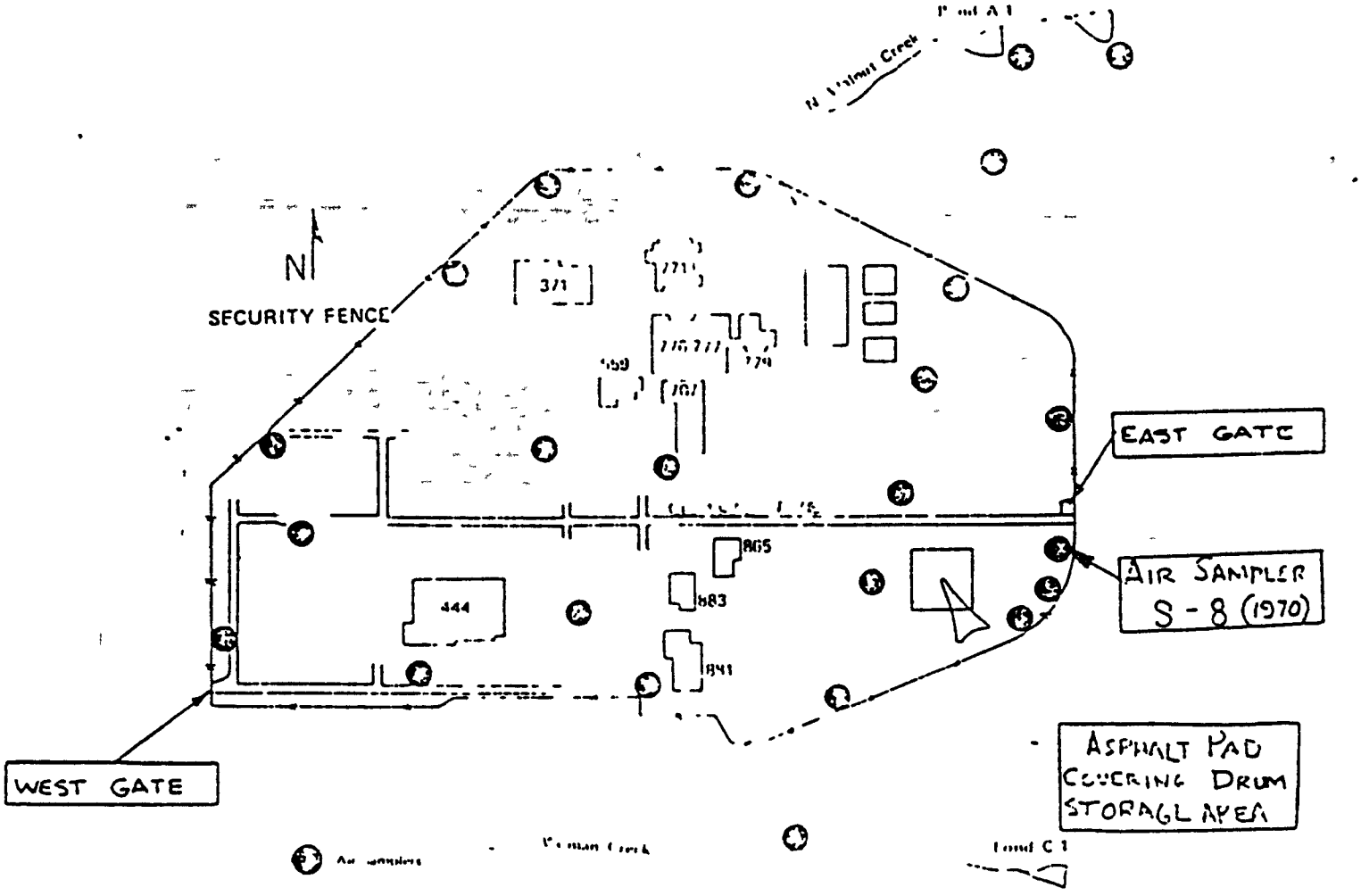


FIGURE 2

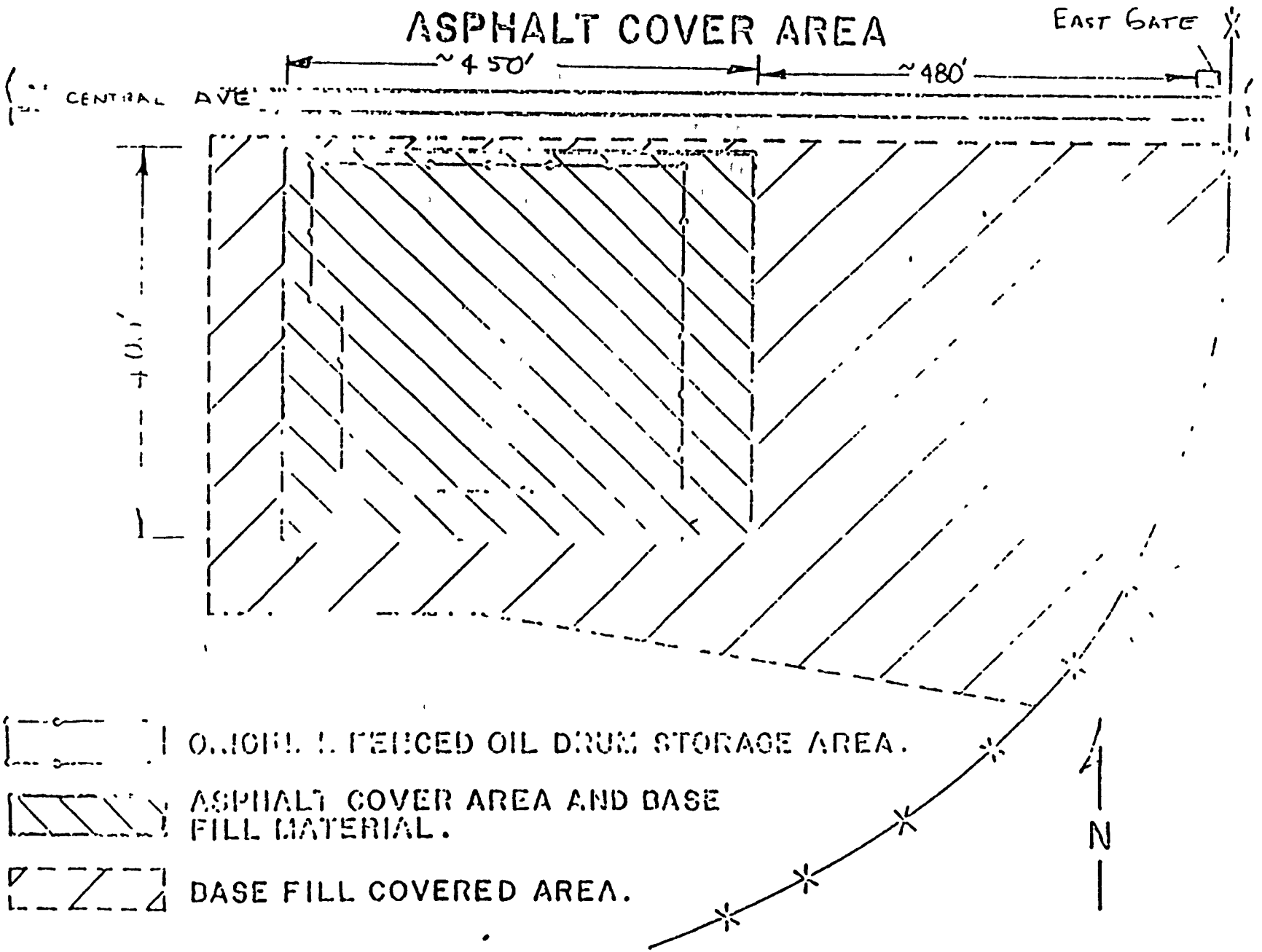


Table 1

Amount Plutonium	How Obtained	Deposition
594 g	Measured on recovery filters	Sent to Idaho for burial
2471 g	Measured in recovered oil	" " " " "
5152 g	Measured adhering to drums	" " " " "
85 g	Maas estimate (see above method)	Leaked into RF soil
8302 g	Total of above calculated originally stored in the 3,570 drums	

The amount stored per drum is calculated to be 2.3 (1.2 to 4.6) grams.

Little[8] quotes another estimate based on maximum discard limits of 2.1 grams per drum. Multiplying this by the 3,570 (Pu barrels stored) gives a maximum estimate of 7,500 grams total plutonium This storage estimate is within the range estimated by Seed[1]-Maas[15]. Little and Seed-Maas estimates were thought to be accurate within a factor of two.

An independent estimate by Krey et al[4,5,6,7] of Rocky Flats origin plutonium in the Denver area (1970) soils of 11.4 Ci ± 20% provides a more precise estimate of the total plutonium release. Seed[1] and Krey[4,6] state that the majority, or greater than 90 percent of the plutonium in area soils is the result of the drum leak and Little[8] states that greater than 99 percent of a release is retained by soils Thus estimates of plutonium released by the drum leak based on Krey data are

$$\frac{11.4\ \text{Ci} \times 9 \times 99}{0.0734\ \frac{\text{Ci}}{\text{g Pu}}} = 138 \pm 28\ \text{g Pu}$$

A maximum estimate of 155 ± 31 grams of plutonium may then be deduced by assuming 100 percent barrel leakage and soil retention factor.

Seed[1] also reported the estimate of R. F. Foster[19]. Foster constructed the contours shown in Figure 3 from all the soil sample results that had been reported (see Table 2).

Table 2

Organization	Date	Number of Samples*	Sample Depth**
RF[1]	Aug. 1969-June 1970	113	3-5 cm
RF[1]	Dec. 1970	~37	1 cm
HASL[4]	Feb. 1970	18	20 cm (most)
CCEI	Aug. 1969	18	1 cm

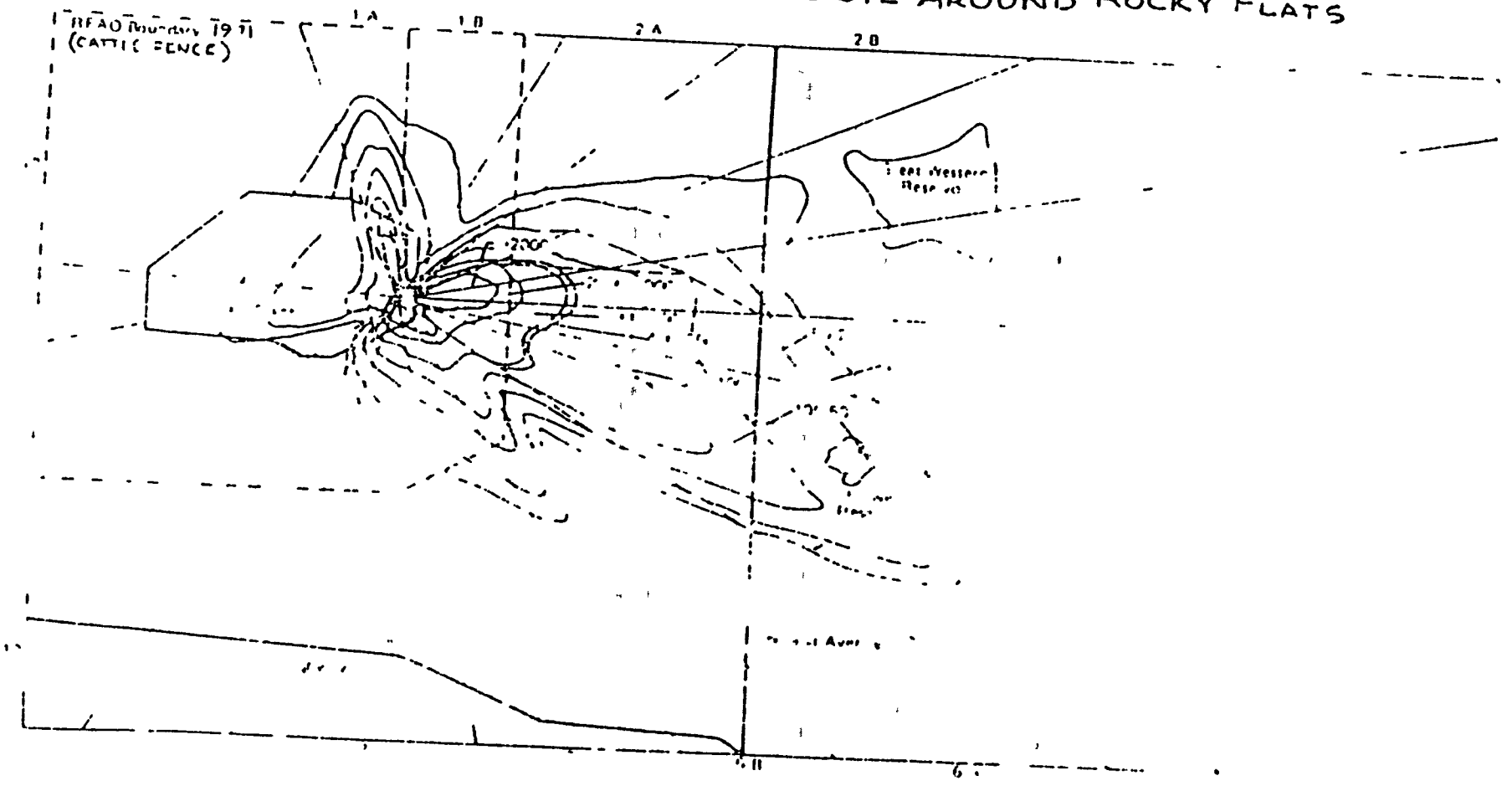
* Results less than 13 mCi/km^2 were assumed to be not distinguishable from background and were not included.

** The plutonium from the May 11, 1969 fire and the drum leak resuspension (mainly 1968) was anticipated to be in the top 1-5 cm of soil with most of the plutonium in the top centimeter.

Integrating over these contours gave 6.7 grams plutonium within the cattle fence (exclusive of the pad) and 7.6 grams plutonium more distant, out to the 13 mCi/km^2 contour for a total of 14.3 grams plutonium exclusive of the pad to the 13 mCi/km^2 limit. This estimate was derived from most of the soil sample data available in 1970 but is not comparable to other estimates because the pad and beyond the 13 mCi/km^2 areas are excluded. Hammond[18] (1971) stated that 5 to 42 grams of plutonium had been released by wind transfer to the environment from the leaking drums. A comparison of these estimates is made in Table 3.

FIGURE 3
(FROM RFP-INV-10)

PLUTONIUM ACTIVITY IN SOIL AROUND ROCKY FLATS



ISOCURIE CONTOUR LINES SHOWING PLUTONIUM ACTIVITY IN SOIL IN mCi/km^2. SOIL SAMPLE DATA FOR THE CONTOUR LINES WERE EVALUATED FOR EACH SECTOR. (LOSER [19])

Table 3

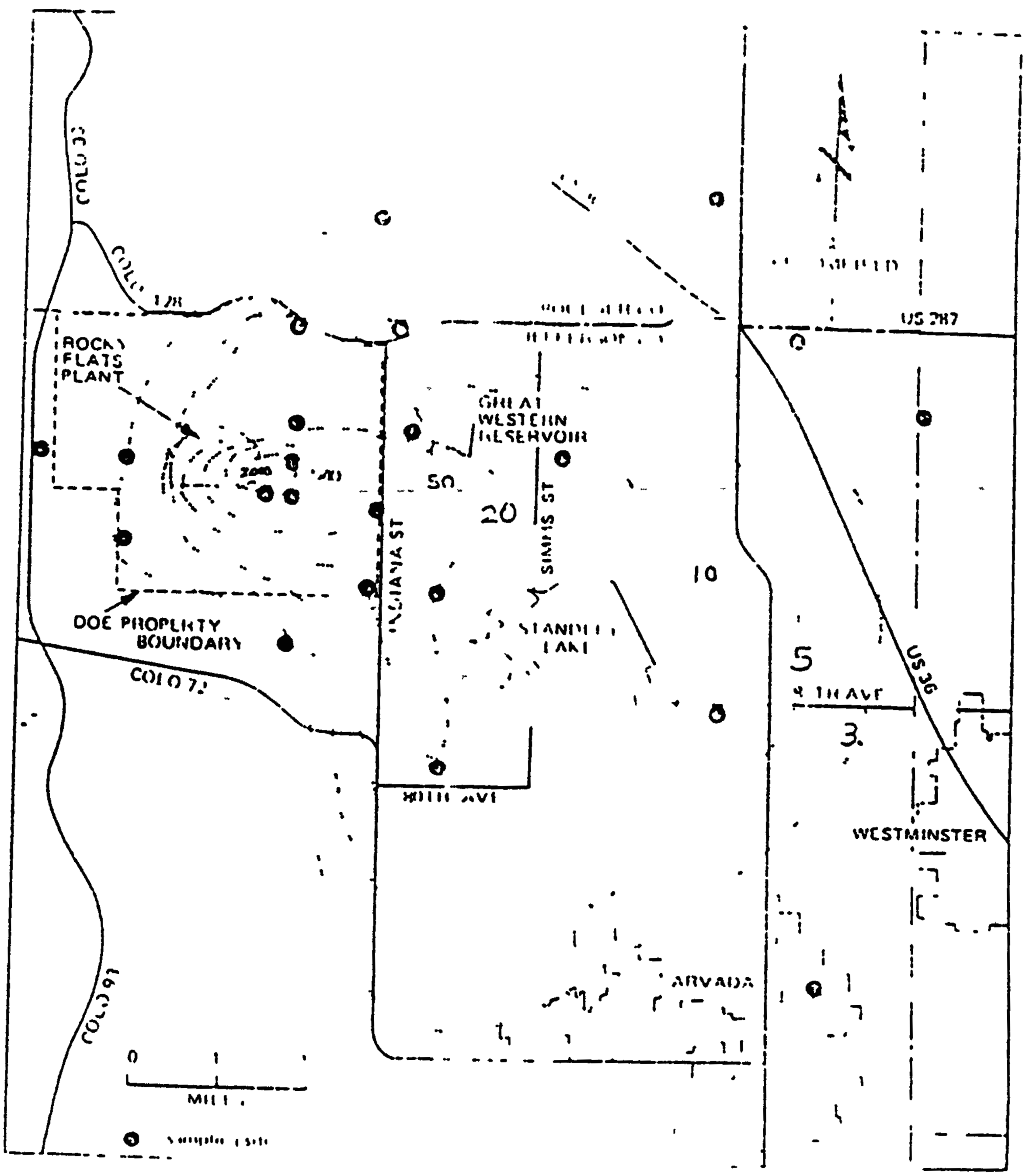
	Hammond[18]	Seed-Hias[1]	Krey[4,6]	Seed-Loser[1]
Minimum	5 g	not estimated	110 to 166 g	17.3 g (Pad-13 mCi/km^2)
Maximum	42 g	43 to 170 g	124 to 186 g	16.3 g (Pad-13 mCi/km^2)

The 1980 Rocky Flats Environmental Impact Statement[16] states that the Krey[4,6] estimate of 11.4 Ci of plutonium in area soils, derived from the data in Figure 4, is the best estimate to date and would be accepted until better information is available.

RESUSPENSION AND REDEPOSITION

The adverse affects of the drum leak result almost entirely from resuspension of the soil contaminated by the leaking drums. The Seed[1] data on the S-8 sampler (see Figure 1) provides a chronology of these releases. This data indicates that although large scale leaking was detected in 1964, airborne releases were not above 0.4 pCi/m^3 (TLLα) until late 1967 when most of the plutonium barrels had been removed. Most of the plutonium was apparently released in 1968 when TLLα values as high as 34 pCi/m^3 were measured after all the plutonium barrels were removed. Offsite plutonium on vegetation analyses (Hammond[3]) indicate a maximum plutonium release between May and October 1968. Releases continued into July 1969 when the "temporary" storage area was covered with dirt fill. The storage area was coated with asphalt in November 1969. Plutonium found on offsite vegetation in 1969, 1970, 1971 (Hammond[3]) indicate additional plutonium releases possibly resuspended

FIGURE 4



[illegible] 239 [illegible] Around Rocky [illegible]
[illegible] from [illegible] 1970 (mCi/km²)

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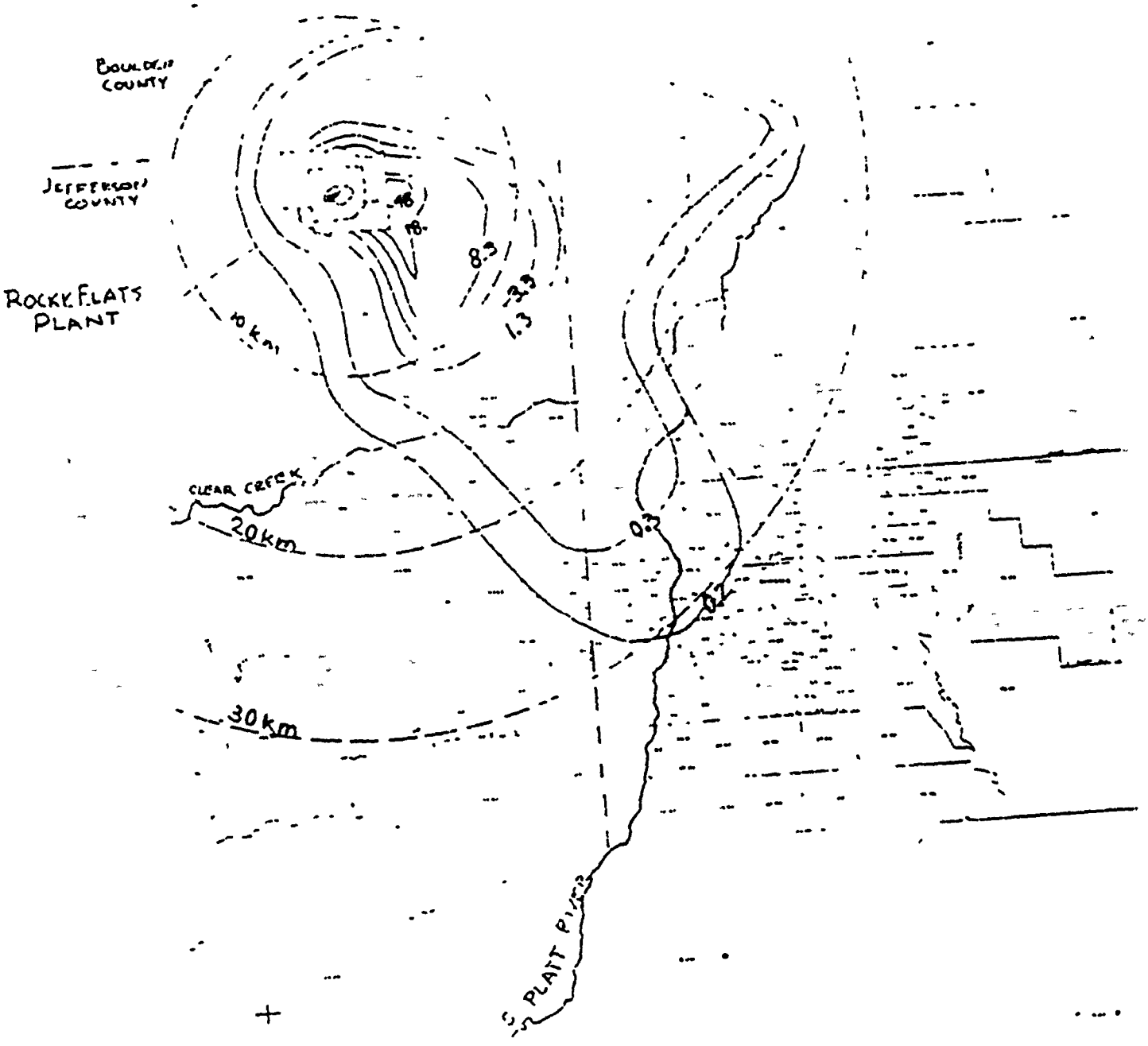
16

from areas not covered by the fill or pad. Seed[1] states that airborne concentrations never exceeded the USAEC applicable surface air standard for radiation workers of 2 pCi/m^3

The estimates of the spatial distribution of the plutonium given by Seed[1] (Figure 3), Krey (Figures 4 and 5), and Langer (Figure 6) do not agree especially well. However; as noted in Table 1, the total release estimates compare acceptably well within their limits of uncertainty

FIGURE 5

* PLUTONIUM ACTIVITY IN DENVER AREA SOILS (1976)



ontours of Rocky Flats ^{239,240}Pu activity in pCi/m^2. Values decrease
om a high of 48 for the innermost contour to values of 18, 8.3,
3, 1.3, 0.3 and 0.2 as distance from the Rocky Flats plant
ncreases. (REF KREY[17])

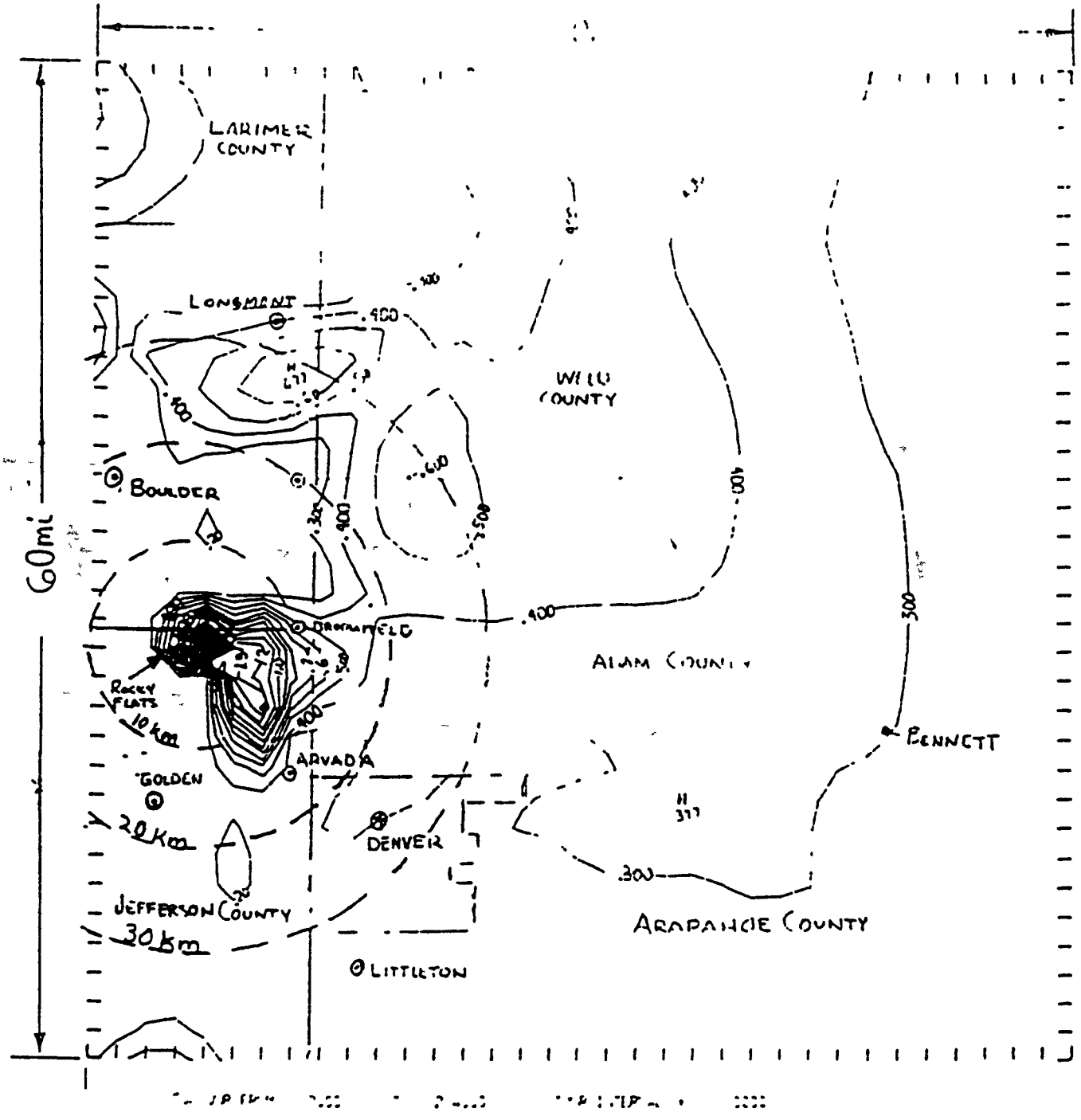
SCALE

* PLUTONIUM ACTIVITY DUE TO ROCKY FLATS OPERATIONS. AN ADDITIONAL 1.7 mCi/Km^2 RESULTED FROM "GENERAL ATMOSPHERIC WEAPONS TEST FALLOUT" (KREY[6])

01705

FIGURE 6

*COMPUTER PLOTTED CONTOURS OF PLUTONIUM ACTIVITY IN DENVER AREA SOILS (SAME DATA POINTS AS FIG 5)



CONTOURS LABELED WITH LOG10 Pu CONCENTRATION (mC./km²), ie.

.200 = 1.58 mC/km²	.500 = 3.16 mC/km²	1.2 = 15.8 mC/km²
.300 = 1.99	.600 = 3.98	1.5 = 19.9
.400 = 2.51	1.00 = 10.0	2.4 = 251

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INTRODUCTION

On Sunday, May 11, 1969, an overheat alarm at 2 27 p m was the first detection of a fire in the North Plutonium Foundry glovebox line of Building 776 The fire burned vigorously through combustible materials in connecting gloveboxes in Building 776 and 777 and was under control four hours later at 6 40 p m. All fires were out by 8 00 p m Small spot fires rekindled infrequently during the night and into early Monday morning. There were no serious injuries but there was one fire fighter who inhaled plutonium in excess of the maximum permissible lung burden. The fire, smoke and radioactive contamination damage was extensive in the operating areas of 776 and 777 Buildings.

Minor contamination was tracked outside the buildings to nearby buildings. The restoration property loss (through October 1977) was 26.5 million dollars[2, 7]. The costs estimated in September 1969[1] were:

Plutonium fabrication work lost and recovery	22.3 million dollars
Damage to buildings, equipment and decontamination	48.4 " "
	70.7 " "

The apparent differences in the 1969 and 1977 numbers are plutonium rework, and replacement estimates versus restoration cost. Although there were a few thousand kilograms of plutonium stored in the two buildings, less than 10% was damaged or burned to oxide requiring reprocessing The air filtration system was damaged but not breached and continued to function. Estimates of the plutonium released are.

193 . Ci	March 1970	[10]
210 Ci	1971	[4]
356 Ci	1980	[7]

The black smoke observed between 3:20 p m and 4 10 p m. billowing over the 776 Building roof toward 778 and 750 Buildings was concluded[1] to have resulted from heat decomposing a small section of roofing Firemen cooled the overheated spot with water until 5:00 p m. It was concluded[1] the smoke had not passed the air filtration (HEPA) system but came from the under side of the hot spot through roof vents and there were no penetrations of the roof by the fire.

Perimeter air sampling stations indicated plutonium concentrations in ambient air were well below established standards. The max permissible Pu-239 in air for the general population was 3 X 10^{-14} µCi/ml for soluble plutonium or 3 X 10^{-13} µCi/ml for insoluble plutonium.

About 30 vegetation samples were taken offsite after the fire[5]. Three of these indicated plutonium activity on samples southeast of the plant along Indiana Avenue as follows:

at Woman Creek	179 dpm Pu/kg Veg
intersection with Hwy. 72	180 dpm Pu/kg Veg
intersection with W 96th Ave.	60 dpm Pu/kg Veg
(background, MDA - approx	10 dpm/kg)

One sample due south of the plant on Highway 72 had 83 dpm Pu/kg Veg., and one sample southwest of the plant at the intersection of Highways 93 and 72 had 74 dpm Pu/kg Veg. None of the other 25 vegetation samples from other directions and distances detected any plutonium (apparently less than 10 dpm Pu/kg Veg.).

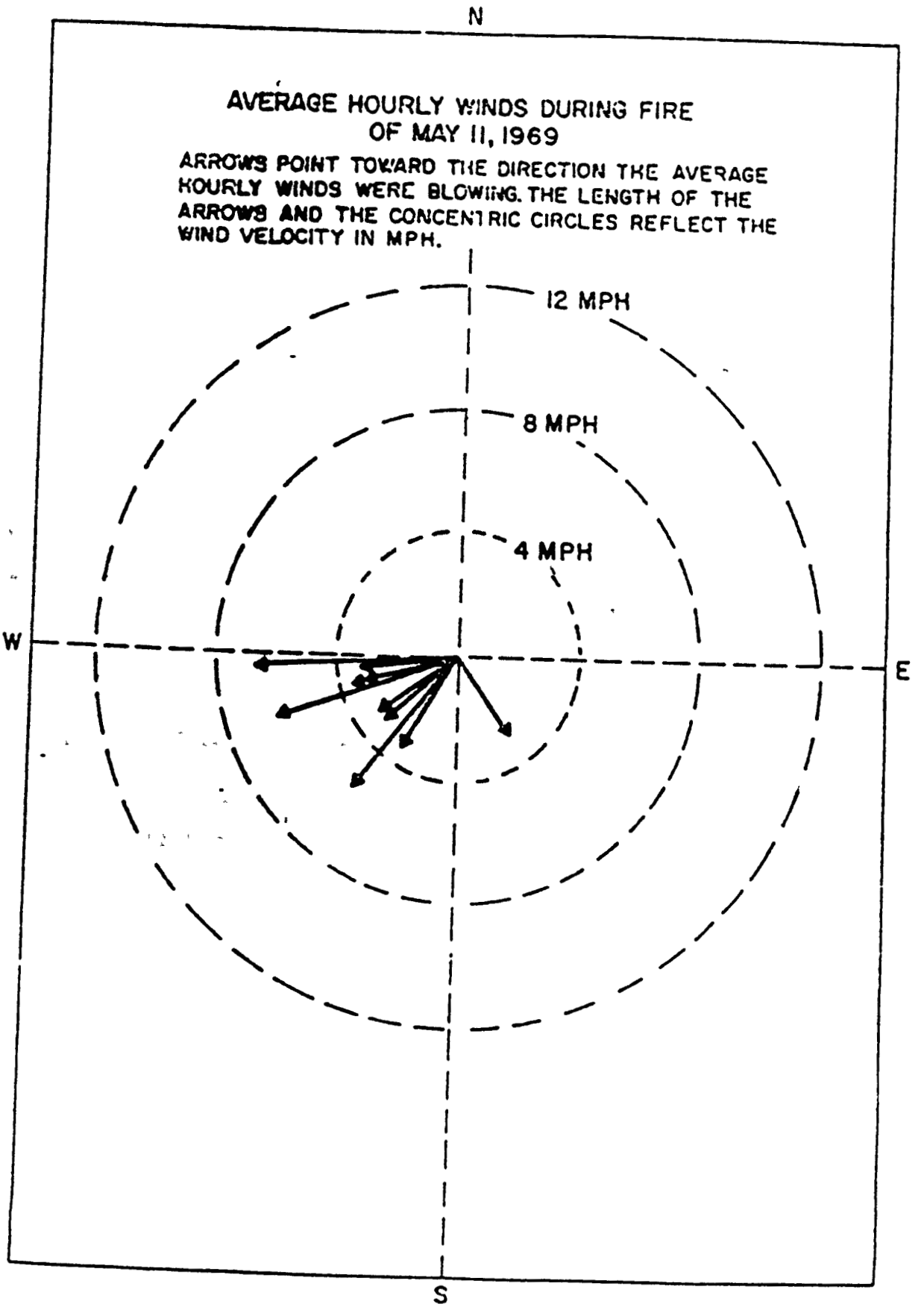
The source of the plutonium found on this set of samples (vegetation was growing April and May) was not determined and could have been resuspended from operations in the oil drum leak area where monitoring indicated resuspension from this source mainly in 1969 but continuing more than a month after the fire through July 1969 when the drum storage area was covered with fill dirt. On the other hand, the drum leak plutonium resuspension is thought to be deposited mainly to the east of the temporary drum storage site where no plutonium was detected in the post fire vegetation samples.

Figure 1 is a plot of the winds measured atop 123 Building during the 1969 fire.

FIRE CAUSE

The cause, time and location of the initiation of the fire could not be determined exactly but it was surmised that a 1.5 kg briquette of scrap plutonium alloy metal (probably oily and possibly with carbon tetrachloride) contained in a metal can 5-1/2 inches deep, 4 inch diameter and probably without a lid, spontaneously ignited. Subsequently this and other plutonium metal ignited Plexiglas and Benelex and other combustibles. One million

FIGURE 1



one hundred seventy thousand pounds of Plexiglas® and Benelex® had been added after March 1968 in Buildings 776 and 777 for neutron shielding. There was no previous record or recollection of any fire in the (alloy) briquette storage glovebox 134-24 where the fire was thought to have started.

There were no operators working in the area Sunday, but fire watchmen had periodically (last check 2:00 p.m.) observed the gloveboxes near the location where the fire apparently started within 30 minutes prior to alarm detection of the fire and the fire watchmen had not noticed anything unusual. Note that plutonium metal burns at a temperature near the 640°C melting point of plutonium and is not visible and no odor, smoke or flames are produced until other combustibles are involved. Post fire examination of Utilities recordings detected a static pressure change in the glovebox dry air system at 2:18 p.m. (synchronization with other clocks ± 10 minutes). The fire was first detected by a box overheat alarm at 2.27 p.m. followed by another overheat alarm at 2:29 (± 3 minutes). The Utilities operator on the second floor of 776 Building smelled and saw smoke coming through floor openings about the same time and turned in a manual alarm at about 2:33 p.m. A fourth alarm was recorded at 2 35 p.m. when firemen began using water from fire hoses. (Firemen had decided to use water less than 10 minutes after arriving at the fire).

Fire fighting efforts were rated excellent and heroic. The use of water on burning plutonium did not produce hydrogen explosions (only "showers of sparks") and there was no nuclear criticality at any time.

Investigators found no evidence the fire was intentionally started

Following the fire, Hartell[11] reported analyses of plutonium in the Denver area soils and concluded more than a curie of plutonium had been released in the May 11, 1969 fire Extensive analysis and investigations reported by Krey (1970)[12], and Seed (1971)[3] concluded most of the plutonium in Denver area soils near Rocky Flats was from the oil drum leak incident (1958-1969) and that other plutonium in soils more distant from the Rocky Flats Plant was from worldwide (weapons) fallout.

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REVIEW OF THE TRITIUM RELEASE OCCURRENCE AT THE ROCKY FLATS PLANT MARCH THROUGH OCTOBER 1973

INTRODUCTION

A shipment of scrap plutonium received by Rocky Flats (RF) March 19, 1973 from Lawrence Livermore Laboratories (LLL) for recovery and reprocessing of the plutonium contained an unanticipated and unmeasured amount of tritium later estimated to have been 500 to 2000 Ci. The tritium contaminant was not detected at LLL Shipping or RF Receiving, Processing or Waste Control, nor was there any mention of tritium or suggestion of previous tritium contamination in the shipping papers. The tritium release was not recognized and confirmed until early September 1973. The source of the tritium was identified and reported[1] November 26, 1973.

The scrap plutonium had been processed April 9 through 25 by procedures approved for plutonium (nontritiated) recovery, and waste processing before discovery of the tritium contamination. Since the process was not designed for tritium control, an estimated 350 to 1600 Ci of tritium was released in exhausted air and 150 to 400 Ci was located in process and waste waters. Processing of the waste waters had resulted in 100 to 300 Ci tritium in onsite tanks, basins and ponds and 50 to 100 Ci in the Great Western Reservoir (avg. 0.01 μCi/l for 3 months[2]).

RECOGNITION OF THE PROBLEM

The plutonium scrap, later identified as contaminated with tritium, was received March 19, 1973. The radioactive gas monitoring instrument in the receiving building (554) did not indicate tritium. The cause of this was not reported but three possibilities are:

1 The instrument was intermittently used and was not turned on

2. The instrument did not have sensitivity to detect the tritium through seals

3. The tritium detected could not be distinguished from interfering engine exhaust gases

Thus, the problem was not recognized at this time and the scrap was processed without any further monitoring for tritium

Prior to this (1972) RF personnel trained Colorado Department of Health (CDH) personnel in environmental tritium sampling and analysis, and had instituted a sampling program for tritium and other radionuclides. Tritium sample results during 1972 showed good agreement at background levels (500-1000 pCi/l) between CDH and RF. In 1973 environmental samples were not checked for tritium by RF prior to September. CDH sampled plant effluent during the entire year, and on April 24, 1973, a routine monthly water sample collected by CDH from Walnut Creek at Indiana Avenue indicated what was later identified as tritium. At the time, however, it was not distinguished from possible chemical interference. On May 24, 1973, another similar CDH sample from Walnut Creek indicated higher results equivalent to 3,000,000 pCi/l tritium which equalled the maximum permissible concentration specified for uncontrolled areas and which was well above background level.

CDH questioned RF by telephone (approximately three calls June 26 through August) and at a June 26 Information Exchange Meeting Rocky Flats had no knowledge of any tritium being processed, and did not believe the known small quantities of tritium in sources, targets, etc on the plant site could have accounted for the anomolous results. Colorado Department of Health

continued sampling after May 1973 and these samples showed decreasing concentrations each month. The subject of tritium was discussed again by CDH in the July 31 Information Exchange Meeting with RF. It was agreed to request that the Environmental Protection Agency (EPA) perform confirmatory sampling. The EPA confirmed elevated tritium levels the week of September 6, 1973.

On September 13, 1973, CDH and EPA personnel toured Rocky Flats Plant facilities and obtained additional water samples to be analyzed by several EPA and USAEC laboratories. These analyses all verified elevated tritium levels in Rocky Flats effluents.

A letter[2] was written by CDH to the Governor of Colorado on September 14 asserting that (subject to confirmation) Rocky Flats was the probable source of a release of tritium which caused tritium concentrations equal to the maximum allowable in Walnut Creek waters. The release started in April, reaching the maximum in May and had declined after that. The Broomfield water supply remained at a much lower concentration and had not reached or exceeded the guide levels for drinking water.

Internal searches and audits for a source of tritium by Rocky Flats starting in June and continuing through September were unable to find a probable tritium source.

Finally, on September 20, 1973, H C Donnelly (USAEC Manager of Albuqueque Operations Office) appointed an AEC investigating committee with Donald Ofte as Chairman. This committee investigated and reported[1] the probable source of the tritium 11/26/73.

COSTS AND LOSSES

The cost for onsite decontamination was estimated to be $1,971[1] but was later reported[3] to have been [illegible] nor occupational exposure exceeding the 3 rem per quarter or 5 rem per year guidelines

The tritium released offsite was determined to not have posed a public health hazard. It was calculated a typical Broomfield resident drinking Great Western Reservoir water in 1973 would receive less than 1.4 millirem compared to a maximum permissible level of 170 millirem.

Perhaps the greatest loss was to plant credibility as evidenced by more than 100 articles unfavorable to Rocky Flats handling of the incident.

There were expenditures to improve Rocky Flats receiving and effluent air and water monitoring capabilities including the following:

All shipments of radioactive materials are checked for tritium and other beta activity emissions.

Two wide beta analytical instruments were purchased and are used by Rocky Flats to monitor tritium and other beta activity emitters in buildings, plant effluents and environmental samples

Exhaust air from buildings reprocessing nuclear materials is routinely monitored for tritium.

REFERENCES

1 Otte, Don (Chairman), [illegible] (Investigating Committee Members), Investigation of the Tritium Release Occurrence at the Rocky Flats Plant, November 26, 1973

2 Cleere, Roy L. and Robert D Siek to Honorable John D Vanderhoof, Governor of Colorado, correspondence, September 14, 1973 (Copy with Ref. 1)

3 United States Department of Energy, Final Environmental Impact Statement, DOE/EIS-0064, Rocky Flats Plant Site, Golden, Colorado, April 1980.